Background material for presentation on the Integrated Project: The Gulf of Alaska Project

The Gulf of Alaska (GOA) is of immense cultural value to Alaska and economic value to the country. It is a large ecosystem with a complex downwelling current structure that supports fisheries for walleye pollock, Pacific cod, rockfish, sablefish, halibut, salmon, and herring. The cultural value of the GOA is demonstrated by the large number of communities located on its coast, the bulk of Alaska's population lives within sight of the GOA. Its economic value is demonstrated by the fact that approximately a third of the total landings in the US come from the GOA (http://www.st.nmfs.noaa.gov/Assets/commercial/fus/fus14/documents/FUS2014.pdf) and in 2014 these landings represented enough protein to feed everyone in Philadelphia for a year.

Status of Ecosystem Modeling, Integrated Analyses and Cumulative Analyses

There is a long history of ecosystem research in the GOA. For the AFSC it begins in the early 1980's when scientists from the FOCI program (http://www.ecofoci.noaa.gov/) began to combine oceanographic observations with the results of larval surveys to understand the sources of variation in walleye pollock recruitment. In the late 1990's AFSC scientists initiated a coastwide survey for salmon in the Gulf of Alaska that extended the FOCI model by linking oceanographic observations with data describing fish collected from the epipelagic (http://www.afsc.noaa.gov/ABL/MESA/archives/mesa_occ.htm). This program led to a model that currently produces accurate predictions of pink salmon returns to southeastern Alaska. The North Pacific Research Board and AFSC teamed-up in 2010 to start the Gulf of Alaska Integrated Ecosystem Research Program (GOAIERP), which was intended reveal the environmental forces that constrain recruitment of key groundfish species (http://www.nprb.org/gulf-of-alaska-project). That program integrated the results of fisheries oceangraphic surveys and modeling to describe the factors limiting recruitment of key groundfish species in the GOA. Today, that program has morphed into the Center's Gulf Survey (http://www.afsc.noaa.gov/ABL/EMA/EMA_GOA.php), which continues to monitor juvenile groundfishes.

Other surveys conducted by AFSC in the GOA include the annual Bottom-trawl survey, Long Line survey and semi-annual acoustic surveys. These surveys are conducted in support of stock assessments and have provided data to support an EcoPath model (http://www.afsc.noaa.gov/Publications/AFSC-TM/NOAA-TM-AFSC-178.pdf). In addition, diet information from all surveys conducted in the GOA has recently been made available over the web . This includes thousands of observations spanning several decades of collections.

There are two important reasons motivating the Gulf Survey's focus on understanding and monitoring juvenile groundfish recruitment processes. First, monitoring is intended to lead to a model for recruitment that can improve the accuracy and precision of stock assessments, much like the pink salmon model. Development of such a model would allow managers to anticipate changes in production. Second, understanding and monitoring the recruitment process offers a better avenue for predicting how populations will respond to climate change. Juvenile fish are more susceptible to environmental conditions; they have fewer energy reserves, higher mass specific metabolic demands, more predators and fewer prey items than larger fish. Consequently efforts to relate juvenile survival

to environmental conditions offers the best chance of predicting the effects of climate change on future production.

The Gulf Survey is configured to monitor nutrients, chlorophyll, water temperature, salinity, zooplankton and epipelagic fish abundance in a grid of stations located on the eastern and western sides of the northern GOA. Fish samples collected on the surveys are retained to evaluate size, diet and energy density. We relate environmental conditions to the distribution, abundance and condition of juvenile fish using bioenergetic analysis. The bioenergetics analysis integrates the effects of lower trophic productivity on food abundance and quality, impacts of predators and competitors on prey availability and temperature into indices that relate directly to the potential survival of fish. The focus of this presentation is how we are applying bioenergetics to monitor recruitment processes in the GOA.

Important findings to date using our approach include the observation that indices of future production are species specific. Pelagic sampling may adequately index future production of some species, such as walleye pollock, but others, like Pacific cod, are likely best indexed after they settle out of the pelagic. This conclusion, drawn from comparing spatially explicit models of pollock and cod growth potentials, is supported by conclusions drawn from IBM modeling, evaluation of recruitment variability, and diet analysis. Settlement incurs energetic costs that cannot be measured when only sampling the pelagic phase and these costs can be significant. Moreover, demersal life history stages employ a different energy allocation strategy after settlement than used during the pelagic phase, indicating that constraints on survival post-settlement differ from earlier stages. Consideration of the bioenergetic response of juveniles to different life history stages and environmental conditions reveals the optimal periods to monitor in order to predict recruitment.

Inclusion of the Ecosystem Data into Living Marine Management Advice

Data generated during the Gulf Survey is cataloged in the Ecosystems Considerations Chapter to the SAFE document produced annually for the NPFMC. These data include observations of marine conditions, descriptions of zooplankton communities, and condition of juvenile fish. In addition, Species Specific Report Cards have been developed and are included in annual Assessments. Analyses of survey data are used to identify species specific indices that have predictive value for recruitment. These indices are calculated and included in annual report cards, providing managers with information regarding the potential for future production.

Peer Reviewed Ecosystem Science Related Program and Products

Research products from surveys are routinely published in peer reviewed journals. The GOAIERP resulted in two special issues of Deep Sea Research and a third is planned. AFSC maintains a culture of publishing work in peer reviewed journals.

Communication to Managers, Partners, Stakeholders and the Public

AFSC ecosystem research findings are shared with managers and stakeholders through the North Pacific Fishery Management Council, partners and the public are informed through outreach at professional meetings and publications. Annual summaries of ecosystem science are also provided to the NPFMC Plan Team. Research findings are also communicated annually to managers, partners, stakeholders and the public at the Alaska Marine Sciences Symposium. Each January approximately

1000 marine scientists and policymakers meet to discuss research findings specifically having to do with Alaska's marine ecosystems. Disciplines featured in plenary sessions include oceanography, fisheries biology, ornithology, marine mammalogy, economics and social science. The meeting is free to the public.